ASSESSMENT OF WATER QUALITY OF DIFFERENT COAL WASHERIES

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

BACHELOR IN TECHNOLOGY

IN

MINING ENGINEERING
BY

Pulack Ranjan Nayak

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DEPARTMENT OF MINING ENGINEERING
NATIONAL INSTITUTE OF TECHNOLGY
ROURKELA-769008
2015-2016

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UNDER THE GUIDANCE OF

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DEPARTMENT OF MINING ENGINEERING
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NATIONAL INSTITUTE OF TECHNOLOGY

ROURKELA

CERTIFICATE

This is to certify that the thesis entitled **"Assessment of Water Quality of Different Coal Washeries"** submitted by **Pulack Ranjan Nayak** in partial fulfillment of the requirements for the award of Bachelor of Technology degree in Mining Engineering at National Institute of Technology, Rourkela (Deemed University) is an authentic work carried out by him under my supervision and guidance.

To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other University/Institute for the award of any Degree or Diploma.

Date:

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ABSTRACT

Indian coals are believed to be of drift origin and so it is necessary to wash in washery. A huge quantity of water is required in coal washing. A plant with a capacity of 100 tons of coal/h would require in the course of 8h shift from 600,000 to 2,000,000 gallons of water. This feed water in the working process comes out from the coal preparation plant in the form of effluents, containing the dirty minerals and impurities associated with the raw coal. For this water quality analysis was conducted out in three washeries -Balanda coal washery, Talcher, Ib valley coal washery, Jharsuguda and Himgir coal washery, Sundergarh. The project was carried out with the following objectives:

- To assess the water quality of different samples from three coal washeries.
- Compare the analyzed characteristics of water samples with Indian Standards.

Water samples were gathered from three coal washeries which are Balanda coal washery, Talcher, Ib Valley Coal Washery (Samleshwari), Jharsuguda, Himgir coal washery, Sundergarh of Mahanadi Coalfields Ltd (MCL). Based on the Water quality analysis the following conclusions were made:

In this present work, water samples were gathered from three coal washeries namely Balanda coal washery, Talcher, Ib Valley Coal Washery (Samleshwari), Jharsuguda, Himgir coal washery, Sundergarh of *Mahanadi Coalfields Ltd (MCL)* analysed for 17 water quality parameters using procedure of APHA,1998. Based on the water quality analysis the following conclusions were made:

In Balanda coal washery, Talcher all the water samples were examined and found that the pH of S2, S3 and S4 had a quite low pH which is acidic and tends to be corrosive but the pH of S4 was within the permissible limit. MOEF Schedule VI Indian Standard (2006) indicates that it ought to be inside 5.5-9.0..Also the water samples S1, S2, S3 and S4 (108 to 184 NTU) had turbidity beyond the permissible limit. MOEF Schedule VI Indian Standard (2006) indicates that it ought to be inside 10 NTU. The parameters like TDS and conductivity were also within the permissible limit. The BOD of S1 was comparatively higher but all water samples were beyond the permissible limit and COD of all water samples were beyond the permissible limit except S4. The water sample S1 had a very high content of hardness in comparison to other samples but parameters of all samples like sulfate, phospahte, fluoride and nitrate were within the standard limits.

In Ib valley coal washery (Samleshwari), Jharsuguda all the water tests were investigated and found that the pH all samples were within the permissible limit. Also the water samples S1, S2, S3 and S4 (130 to 1674 NTU) had turbidity beyond the permissible limit but some of the parameters like TDS and conductivity was also within the permissible limit. The BOD of S4 was comparatively higher but all water samples was beyond the permissible limit and COD of all water samples was beyond the permissible limit. The water sample S4 had a very high content of hardness in comparison to other samples but parameters of all samples like sulfate, phosphate, fluoride and nitrate were within the standard limits.

In Himgir coal washery, Sundergarh all the water samples were analyzed and found that the pH of all samples were within the permissible limit. . Also the water samples S1, S2, S3 and S4 (130 to 162 NTU) had turbidity beyond the permissible limit but some of the parameters like TDS and conductivity was also within the permissible limit. The BOD of S3 was comparatively higher but for all other water samples were beyond the permissible limit and COD of all water samples was beyond the permissible limit but parameters like sulfate, phosphate, fluoride and nitrate were within the standard limits.

Based on the above observations and conclusions, it can be inferred that treatment for some of the water quality parameters is highly required. So pH can be treated by soda ash (sodium carbonate) and sodium hydroxide which raise the pH of water to near neutral when injected into a water system and also neutralizing filter is used if drinking water is acidic (low pH).Using suitable cost effectives primary and secondary treatment, sedimentation and coagulation treatment as well as chemical treatment the TDS and turbidity, and pH control BOD and COD can be removed substantially /reduced below permissible limits. Hardness can be treated by using chemical water softeners and mechanical water softeners which alter calcium ions so they cannot cause lime-scaling. It is also recommended to use appropriate low cost water treatment options for treating objectionable parameters before water use/discharge receiving water bodies.

Key Words: Coal washery, water quality, BOD, COD, TDS

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CHAPTER-1

INTRODUCTION

1. INTRODUCTION

Coal plays an important role in industrial development of India as it is not only the prime source of commercial energy both in the present scenario and in the near future, but is also a major mineral fuel. Fortunately, India is endowed with a large resource of coal, the total production during 2003–2004 being 352.30 Mt, which is likely to grow to 405.00 Mt by the end of 2006–2007. The mineral matter in coal may be present in a finely divided state and uniformly distributed throughout the coal and this is called 'intrinsic' or inherent mineral matter. It may also occur as segregation in the form of bands and lumps of varying size and thickness, which is termed 'extrinsic' mineral matter. Intrinsic mineral matter represents the inorganic constituents derived from the plants themselves and as such is inherent or original to coal itself. This cannot be removed by washing. Extrinsic mineral matter in coal is easily amenable to removal by washing. Water is the most surely understood medium for transporting material in beneficiation plants and thus most coal separations happen inside this medium. Possibly the best and the most long-standing issue in coal beneficiation plants is the exchange of spouting, which contains a suspension of fine solids.

1.1 Coal washeries

Coal washing is a process of separation mainly based on difference in specific gravity of coal and associated impurities like shale, sand and stones etc. so that we get relatively pure marketable coal with add on calorific value of the coal. Coal washing separates non-combustible material from useful combustible material. Coal washing uses gravity separation, flotation and a technology, which uses dense media. In India dense medium cyclones are most popular as it gives very high separation efficiency Mostly magnetite is used as dense media. Magnetite having specific gravity in the range of 4.8 to 5.4 is used in washery for washing process which is ground to –325 mesh and mixed with water to maintain the desired gravity in HM Bath or HM Cyclone for separation of coal from its impurities.

Indian coal has a very high NGM (Near Gravity Material) which is between 25-30 % and it's difficult to wash it. Dense medium cyclone provides best solution for Indian coal. With around 221 billion tons of non-coking coal deposits, India has huge advantage in developing coal-based sponge iron technology in India. A country having no significant resources of either coking coal or natural

gas can leverage washed and beneficiated coal causing value addition of coal by way of reduction in ash percentage.

Coal beneficiation is a physical system wherein the unrefined coal is pounded in crusher, screened and secluded through wet fascination process in Batac jig. The rejects made from the beneficiation is a bit of the coal which contains more blazing trash thusly not used for metallurgical methodology. The rejects involves carbonaceous shale and coal which has less carbon rate. Rejects are assembled in reject cover in the washery from where it is dispatched to dump zone. The beneficiation consists of cleaning of raw coal by separation of mineral matter (ash) from the coal. How extensively the coal is cleaned before use depends on the purpose for which it is mined and on the specifications it must meet for its use.

The cleaning of coal is mainly based on separation of the impurities by physicochemical methods based on the differences in the specific gravity of coal constituents and on the differences in surface properties of the coal and its mineral matter required. The wastes characteristics from coal preparation plant are highly dependent on the raw coal utilized and the final product. Presently, there are 19 coal washeries (15 in public sector and 4 in private sector) with 33.28 MT per annum in existence. Similarly there are 31 coal washeries for washing non-coking coal (7 in public sector and 24 in private sector) with an installed capacity of 97.32 MT per annum.

Table 1.1 Statistics of coal washeries (EIA Guidance manual-coal washeries, 2010)

Coking Coal	
Location	Capacity (MTY)
Dudga-II	2.00
Bhojudih	1.70
Patherdih	1.60
Sudamdih	1.60
Moonidih	1.60
Mahuda	0.63

BCCL	9.13
Kathara	3.00
Swang	0.75
Rajrappa	3.00
Kedla	2.60
CCL	9.35
Nandan	1.20
WCL	1.20
CIL (07-08)	19.68
Non Coking Coal Washeries	
Dudga-I	1.00
Madhuban	2.50
BCCL	3.50
Gidi	2.50
Piparwar	6.50
Kargali	2.72
CCL	11.72
Bina	4.50
NCL	4.50
CIL (07-08)	19.72
CIL is planning to set up 19 coal washeries with total capacity of 100.6 MTY by 2011-12	

Ministry of Coal identified coal washing as an important area aiming at value addition. To reap the benefits of economics as well as environment, Coal India Limited is planning to expand the capacity of thermal coal from 103 MT per annum to 250 MT per annum in the next five years. Also, CIL decided that all new opencast projects of more than 2.5 MT capacity, which are not linked to pithead power stations should be designed with an integrated washery.

Discharge of coal washery effluents gives rise to the serious problem of visual and aesthetic pollution. The appearance of these effluents during discharge from the outlet of washery premises, in general are black/ brownish-black in color coupled with high turbid appearance and high load of suspended solids particularly in the form of coal fines. The effluent that is produced can contain the parameters that are entitled in the Ministry of Environment and Forest (MoEF) Schedule VI Indian Standards [Central Pollution Control Board (CPCB), 2001] which are to be evaluated in water emanating tests to survey the potential poisons being exchanged from the coal.

1.2 Objectives of the Project

The project work has been planned with the following objectives:

- To assess the water quality of different samples from three coal washeries.
- Compare the analyzed characteristics of water samples with Indian Standards.

CHAPTER-2
LITERATURE REVIEW

2.1 Review of Literature

Gupta and Singh (1993) did different investigation on water contamination issues in coal waheries and its potential to affect water of Damodar river. Coal washeries however were planned on close water circuit, the majority of these in any case, neglect to work on close water circuit subsequently bringing about gigantic amount of effluents containing coal fines also.

They studied into water contamination profile from coal washeries in Jharia coalfield. Different procedure parameters/unit operations in coal washing were additionally portrayed. Effluents from different selected coal washeries of Jharia coalfield were examined and analyzed over a time of six months during 1993. Suspended solids, oil and grease and COD in the washery effluents were recognized as the three noteworthy water quality parameters bringing on heaps of sympathy toward Damodar river contamination. Reasons behind unavoidable release of effluents containing coal fines were also illustrated.

Bandopadhyay (1995) studied on water is the most common medium for transporting

Crushed material in beneficiation plants and hence most coal separations take place within this medium. Perhaps the greatest and the most long-standing problem in coal beneficiation plants is the disposal of effluent, which contains a suspension of fine solids. The washeries are operating on a closed circuit system and hence the effluent generated from the coal washeries containing suspended solids is pumped to settling ponds, in which all fine solids gradually settle and the reasonably clear water is recycled. However, the data available to date are insufficient to define the composition and quantities of effluent as a function of coal type or coal cleaning process variations. The process water and waste characteristics of coal beneficiation plants depend upon the particular process or recovery technique used and the coal processed.

Vlado (1983) did various investigations on coal consumers which require coal of a consistent quality. Coal as mined, known as run-of-mine coal, contains a mixture of different size fractions, sometimes together with unwanted impurities such as rock and dirt. Coal preparation, also known as coal beneficiation, is the generic term applied to the treatment of run-of-mine coal to produce a saleable product of consistent quality as per the required market specification. Basic operations include crushing, sizing, washing, dewatering, drying and blending of the coal. In some cases, the

run-of-mine coal is of such quality that it meets the user specification without the need for beneficiation, in which case the coal is merely crushed and screened to deliver the specified product.

Roy et al. (2003) studied on mining impacts huge zone of the range and its consequences for surface and underground water by including contaminants. They found that the critical wellsprings of liquid effluents were: surface keep running off, mine water pumped put in the midst of drainage operation, spent water from dealing with plants, dust extractors and dust covering systems, effluents from preparation and beneficiation plants, and empties/wash-off out of waste/tailing dumps. Amongst stunning highlights of the destructive mine leakage are low pH and hoisted measures of sulfates, iron, and total split up solids.

2.2 Effect of coal on water

Coal is one of the most-water intensive methods of generating electricity. To meet this necessity mines get surface or ground water supplies from close-by agrarian or household clients. These water assets ones utilized are once in a while returned subsequent to mining due to sullying from polluting influences present in the crease furthermore from the overweight. To upgrade the coals, their washing has to be done and to meet the demand, more washeries will be installed in the area. This will create more serious water pollution problems. Coal washery effluents contain huge amount of suspended solids. The solids in suspension are ultra-fractions of coalfines which are colloidal in nature and possess high coking value. Thus, a good quality of coking coal is being lost along with the effluents. The loss of huge amounts of coal fines shows the ineffectiveness of the present effluent treatment system used in the washeries. Since most of washeries are situated near the river and discharge their effluents in it containing significant amounts of suspended solids the river looks black due to the deposition of coal fines. Apart from the water pollution and siltation on the river bed a good quality of coking coal is being lost in the river. It is a great national loss in the context of energy crisis. Suspended solids, present in the washery effluents, also hinder the movement and development of aquatic life and make the river unsuitable for breeding fish. These also create problems faced by the downstream water works in settling and filtering the suspended solids from polluted water.

2.3 Pollution connected with coal washeries for beneficiation of coal

Coal crease in a portion of the countries has float beginning, realized private mixing of mineral matter with coal, offering rising to more powder substance. Coal washeries are to diminishing ash substance in coal. For coking and non-coking quality change, coal washeries are used. Coal having glide beginning stage, coal-powder allotment in the coal lattice is so cover woven that coal is essentially expected to pummel to smaller sizes for better freedom of coal and slag particles. Coal beneficiation by and large depends on upon gravity contrast amidst coal and powder particles in the wake of experiencing measuring. Amid different operations in coal washeries a considerable measure of particulate matters and vaporous toxins are produced bringing about a genuine air contamination issue in the range. In addition, coal washeries discharge huge measure of solids and fluid waste creating genuine ecological issues.

The washeries decrease blazing flotsam and jetsam substance of coal to 17.5% or less. This method eats up clean water in the extent of 0.2 to 0.25 m3/ton of rough coal data. The washeries are worked in the close water circuit system yet in the meantime around 12-18% of rough water is discharged as gushing. In spite of the way that radiating is managed in settling tank however now and again over-loading results into frustration of close circuit structure. The rejects (15 to 25% of information) are dumped close open region without viewing over relentlessness of dump, in this way dumps near the stream bank cause deterioration of coal particles in the midst of swirling season and storing up of fine coal particles on the base of conduit.

In spite of the way that countless washeries have adequate settling tanks however exchange of solid waste should have been enlivened, especially in making countries to check with the tainting. True blue reject dump organization is obliged to minimize soil breaking down. Another greatly supportive method of making force with the help of washery rejects by using eco-pleasing Fluidized Bed Combustion development. By getting advancement which uses washery rejects, the exchange of fines and rejects can be utilized fittingly and fiscally, as coal of buoy origination require to pound coal before beneficiation and along these lines period of fines are more.

2.4 Strategies for treatment of effluents from coal washery

As indicated by the present ecological practice, it is important to treat the emanating water leaving the tailing lake to evacuate the suspended solids and be reused ideally without making any contamination issue in the downstream water bodies and to keep up attractive water parity. The measure of the suspended solids in the washery effluent were observed to be little and they have every one of the properties of colloids and they don't settle down effectively. They have a tendency to stay suspended in surface water for an uncertain span. The colloids are destabilized or wrecked by permitting them to agglomerate or coagulate into bigger particles and along these lines they can be successfully evacuated. The salt of AI and Fe are observed to be reasonable for this reason. The synthetic poly-electrolytes are also very effective flocculants for removal of suspended solids in aqueous medium. They combine with charged particles causing rapid flocculation and an increased rate of coagulation and settling. The precipitation of a colloid is effected by that ion on an electrolyte which has the charge opposite in sign to that of the colloidal particles. The treatment for the removal of suspended Solid is based on the principle of an extended sedimentation.

CHAPTER-3

SAMPLING & EXPERIMENTAL METHODOLOGY

3. SAMPLING OF WATER SAMPLES FROM WASHERIES

3.1. GENERAL ASPECTS OF SAMPLING

The objective of examining is to gather samples. Agent test implies a specimen in which relative extents or grouping of every single germane part will be the same as in the material being examined. In addition, the same specimen will be taken care of in a manner that no critical changes in structure happen before the tests are made. The accompanying focuses ought to be remembered while gathering water tests (Nollet, 2007) [7]

Initial considerations: A suitable testing outline must be picked on the premise of the circumstance, worldly and spatial procedures of the part of the biological community under scrutiny. Conservation and capacity of the examples ought to be adjusted to secure vital data.

Spatial aspects: The area of examining must be remembered. Notwithstanding that streams in streaming water must be considered. Stratification critically influences the circulation of particles, particularly in lakes. Distinctive separations downstream of a sewage emanating release point must be precisely inspected. Picking the proper profundity is additionally required by the sampler.

Temporal aspects: The worldly variety must be considered painstakingly amid examining as it is of extraordinary significance if nature to be tested shows changes. On the off chance that numerous specimens are to be assumed control over a timeframe, it is fitting to coordinate the inspecting rate to the normal variety in example. Tests containing indistinguishable volumes are taken at consistent time interims if examining is time relative.

Number of samples: The quantity of tests required generally relies on upon the current issue. To get a normal focus a few specimens are gathered according to a general estimation of the essential number of tests.

Sample volume: The example volume relies on upon the components or substances required to be broke down on their normal focus in the specimen. For follow metal investigation test volume of

around 100 ml is adequate by and large. For the examination of natural parameters 1 L tests are ordinarily utilized.

Storage and Conservation: The example volume relies on upon the components or substances required to be broke down on their normal focus in the specimen. For follow metal investigation test volume of around 100 ml is adequate by and large. For the examination of natural parameters 1 L tests are ordinarily utilized.

Contamination: There are dependably odds of pollution of tests amid the examining procedure, either from outside sources or from sullied inspecting or capacity hardware. Polyethylene or Teflon bottles must be utilized for inorganic examination, and glass or quartz bottles in natural follow investigation.

3.2. SAMPLE COLLECTION PROCEDURE

Collection of sample:

- It is ensured that all testing equipment is perfect and quality-ensured before use. Usage test compartments that are perfect and free of contaminants.
- Test compartments were filled without pre-washing with test; pre-flushing results in loss of any pre-included added substance.
- Special protections are fundamental for tests containing take after metals.
- Since various constituents might be presentation at low obsessions, they might be totally or generally lost or easily polluted when genuine looking at and preservation techniques are not took after.

The followings were recorded during sample collection

- General information
- Sample identification number
- Location
- Sample collector

3.3 . SAMPLE COLLECTION FROM THE WASHERY

The samples from the washery are gathered from better places in the washery and the stream sheet of a general washery is given underneath took after by test accumulation.

The Process Flow sheet of the washery is as under:

- Crushing of coal down to 40mm in two phases .Primary Crusher for pounding down to-200 mm in twofold move crusher and optional crusher for squashing down to - 40 mm in the twofold move crusher.
- Stocking of 80-0 mm pulverized coal in 10000 tone opening sort shelter.
- Screening of 80-0 mm Coal at 10 mm in vibratory screens to create two portions viz. 80-10-mm and 10-0 mm.
- De-cleaning of 10-0 mm coal in de-dusters to recuperate dry fines beyond what many would consider possible. The recuperated fines are blended with clean coal.
- Preparation of 80-10 mm coal in a 480 TPH, 4 item Batac Jig to create clean coal, low powder mediocre, high cinder average and rejects.
- De-smearing of 10-0 mm de-cleaned coal in de-smearing screen.
- Preparation of 10-00 mm de-smeared coal in a 300 TPH, 4 item Batac Jig.
- To create clean coal, low fiery debris average, high cinder mediocre and rejects. Dewatering of clean coal from coarse coal Batac coal Jig dewatering screen.
- Crushing of low mediocre in the size extent 80-10 mm down to - 10 mm in effect crusher. The pounded ordinary are then nourished to an arrangement of HM Cyclones along 10-0.5 mm low powder mediocre from little coal Batac Jig to create clean coal and average. A magnetite plan has been accommodated the reason. The plan additionally gives course of action to recuperation of magnetite in two phase attractive separator.
- Dewatering of clean coal from little coal Batac Jig and HM tornados at first in dewatering screen sand at last in axis.
- Initial dewatering of high fiery remains mediocre from little coal Batac Jig and HM twisters dewatering screen lastly in Centrifuge.
- Thickening of 0.5 mm slurry in an outspread thickener.
- Preparation of 0.5 mm thickened slurry in buoyancy cells in circle channels and the channel cake is blended with clean coal.

- Flotation tailings are nourished to a vortex thickener, the undercurrent from which is charged to tailings Lake.
- Arrangement for stocking of clean coal and middling's.
- Stocking of reject in a 300 T reject container and transfer by truck.

A total of 12 tests, 4 from each of the three distinctive coal washeries are gathered and brought.

The four samples vary with their location in the washery. They are

1. Raw water (S1)
2. Fine coal Jig water (S2)
3. Coarse coal jig water (S3)
4. Outlet stream (S4)

The three coal washeries chose for this study are:

Table: 3.2 Water samples with their respective locations and identity

Sl/No.	Location(Coal Washery)	Sample Id	Date of Collection
1	Balanda Coal Washery,Talcher	W1	9-1-2016
2	Ib Valley Coal Washery (Samleshwari), Jharsuguda	W2	6-2-2015
3	Himgir Coal Washery, Sundergarh	W3	10-2-2015

The amount of every sample is around 2 liters and a few locations from where sample is taken:-

LOCATION MAP

Figure 3.1. Balanda coal washery map

Nearby cities: Talcher, Danara, Laxmanpur

Coordinates: 20°55’35”N 85°9’14”E

Figure 3.2. Ib valley coal washery map

Nearby cities: Brajrajnagar, Jharsuguda

Coordinates: 21° 51’N 83° 56’E

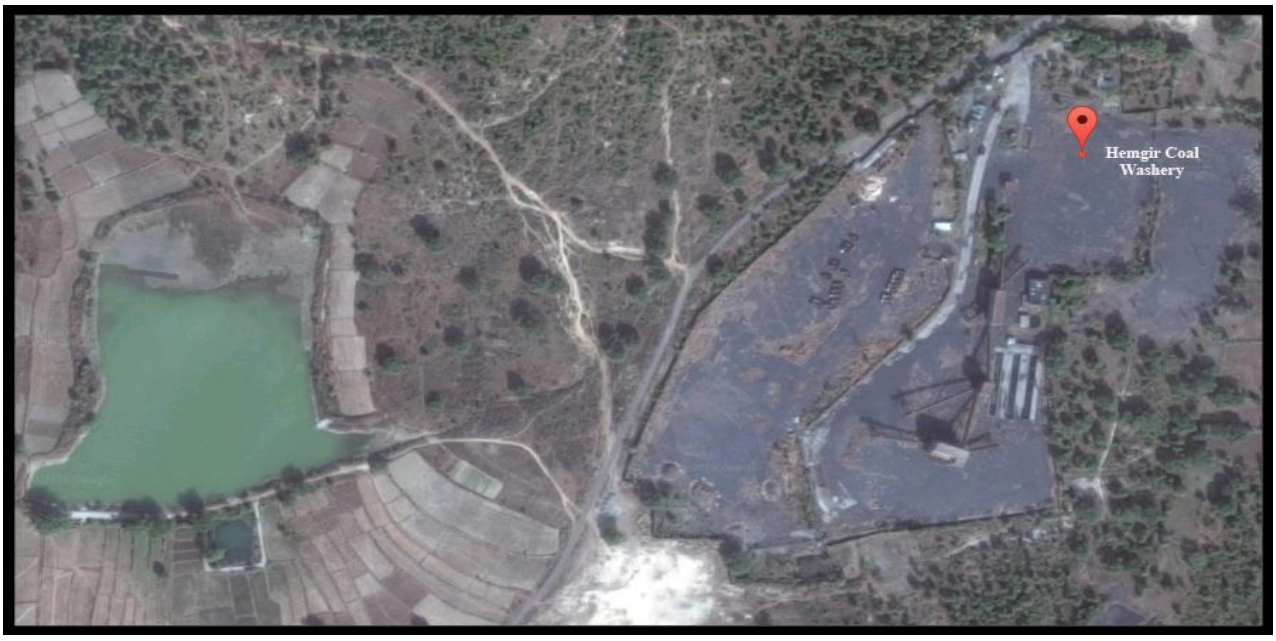

Figure 3.3. Himgir valley coal washery map

Nearby cities: Sundergarh, Sambalpur, Deogarh

Coordinates: 22.116^{o}N 84.016^{o}E

3.4 .Experimental Methodology

3.4.1. Water Quality Assessment

Water quality is physical, chemical and biological characteristics of water. In present work, these attributes are resolved after the rules recommended by the Bureau of Indian Standards and Central pollution control board (CPCB).

The different parameters of interest present in water are extensively put in four classes, in particular physical parameters, inorganic non-metallic substance or chemical mixes, biological or organic parameters.

Physical parameters: This arrangements basically with estimation of the physical properties of a specimen. Large portions of the determinations included here are color, odor, pH, temperature, turbidity, conductivity, oxidation decrease potential (ORP), salinity and total suspended solids.

Chemical parameters and inorganic non-metallic constituents: Hardness, phenol, sulfate, phosphate, fluoride, and nitrate are the concerned parameters while dissecting for inorganic constituents present in water. These constituents influence the nature of water from multiple points of view.

Organic or Biological parameters: Direct determination of the Organic differing qualities and the capacity of water to manage life are troublesome. Subsequently parameters like Dissolved Oxygen content, Bio-chemical Oxygen Demand substance and Chemical Oxygen Demand content aides in reasoning deduction in regards to capacity of the water to manage life in it. Hence these parameters are resolved with most extreme exactness and given significance in this work.

3.4.2. PHYSICAL PARAMETERS

The physical parameters include:

1. Color
2. Odor
3. pH
4. Temperature
5. Turbidity
6. Conductivity
7. Salinity
8. Total Dissolved Solid

3.4.3. Multi water quality checker U-50 series

pH, turbidity, total suspended solids, salinity and temperature are the parameters that are ascertained by Multi Water Quality Checker U-50 Series.

The U-50 Series Multi Water Quality Checker highlights a joined control unit and sensors. It is fit for making a most convincing of eleven synchronous estimations for different parameters, and is ideal for utilization in the field. The U-50 Series is masterminded considering on zone solace, gives a wide accumulation of points of confinement, and can be utilized for water quality estimations and reviews of stream water, groundwater, and waste water.

3.4.3.1. Measurement of pH

Principle of measurement of pH

U-50 arrangement use the glass cathode strategy for pH estimations. The glass anode framework measures a potential many-sided quality between the glass film for pH and the reference cathode.

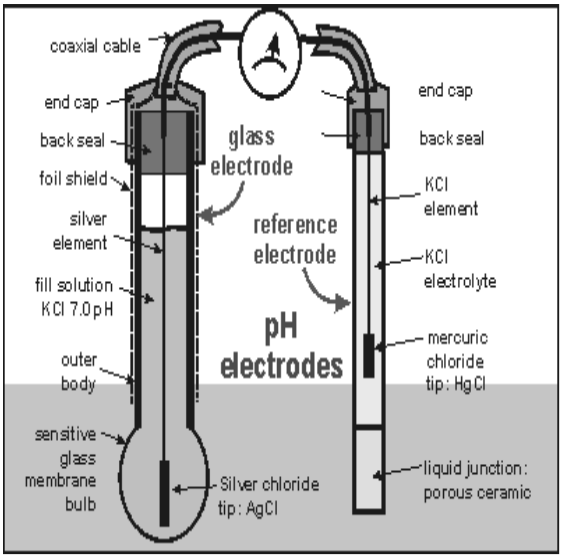

Figure 3.4. Schematic diagram of pH electrodes

3.4.3.2. Measurement of turbidity

U-50 course of action can perform modification using formalin (NTU) or kaolin standard game plans as a turbidity standard game plan. In any case, units for the plan used for arrangement should be appeared in estimations. Do whatever it takes not to use more than 400 mg/L of kaolin standard course of action in light of the way that it grows precipitation rate, achieving estimation slip.

3.4.3.3. Measurement of salinity

The U-50 arrangement is proposed to determine saltiness and moreover exchange parameters. Note that the "saltiness" here is the saltiness of sea water. There is a consistent association amidst conductivity and saltiness at particular temperatures. Thusly, if data on the conductivity and temperature are available, the contrasting saltiness can be known. Toward the day's end, the saltiness estimation of the U-50 game plan is in perspective of the rule of figuring the

salt substance, making usage of the conscious estimations of conductivity and temperature. Note subsequently, that planned outcomes of all substances whose conductivity is perceived are appeared as saltiness. For example, the purposeful result is appeared as NaCl concentrate, paying little mind to the likelihood that to be sure the example fragment is, hydrochloric destructive (HCl).

3.4.3.4. Measurement of Total dissolved solids (TDS)

TDS is short for Total Dissolved Solids and means the total separated solid total. The conductivity of an answer is impacted by the measure of saltiness, minerals, and split up gasses. That is, conductivity is a record that exhibits the total entirety of all substances in the course of action. Of these substances, TDS shows only the measure of broke down solids. TDS can be used for an examination of the state of substances made out of a singular portion, for instance, NaCl. In any case, the usage of TDS for the examination of plans of various sorts causes certified lapses.

Figure 3.5. TDS meter

Conductivity and TDS are expressed by the following formulas.

Conductivity in SI units (S/m)..... TDS (g/L) = L (S/m) × K × 10

TDS (g/L) = L (mS/m) × K ÷ 100

Conductivity in the old units (mS/cm)..... TDS (g/L) = L (mS/cm) × K

K = TDS coefficient

For accurate TDS comparisons, find the TDS coefficient from measured conductivity values. Then set the value thus obtained and make measurements.

3.4.4. CHEMICAL AND INORGANIC NON-METALLIC PARAMETERS

i. Hardness
ii. Nitrate
iii. Phenol
iv. Sulfate
v. Phosphate
vi. Fluoride

3.4.4.1. Determination of hardness: Water hardness is a conventional measure of the limit of water to encourage cleanser. It is brought about by broke up polyvalent metallic particles. In crisp water, the chief hardness bringing on particles are calcium and magnesium which encourage cleanser. Complete hardness is characterized as the entirety of the calcium and magnesium focus, both communicated as $CaCO_3$, in mg/L.

EDTA titration method

Principle:

Hardness is managed by the EDTA system in essential condition. EDTA and its sodium salts from a dissolvable chelated complex with certain metal particles. Calcium and Magnesium particles make wine red shading with Eriochrome dim T in watery course of action at pH 10.0 ± 0.1. Exactly when EDTA is incorporated as a titrant, divalent particles of Calcium and Magnesium get complexed realizing sharp change from wine red to blue which indicates end-reason for the titration. Magnesium molecule must be accessible to yield alluring reason for the titration. From this time forward, a little measure of complexometically unbiased magnesium salt of EDTA is added to the backing. The sharpness of the end point increases with growing pH. In any case, the predefined pH of 10.0 ± 0.1 is an alluring exchange off. At a higher pH i.e. at around 12.0 Mg++ particles encourage and just Ca++ particles stay in arrangement. At this pH murexide (ammonium purpurate) pointer frames a pink shading with Ca++. At the point when EDTA is included Ca++ gets complexed bringing about a change from pink to purple which shows end purpose of the response.

To minimize the propensity towards $CaCO_3$ precipitation confine the term of titration period to 5 minutes.

Procedure:

1. 25 or 50mL very much blended example is taken in porcelain dish or tapered flask.
2. 1-2mL support arrangement is included trailed by 1mL inhibitor.
3. A squeeze of Eriochrome dark T is included and after that titrated with standard EDTA (0.01M) till wine red shading changes to blue, the volume of EDTA required (An) is noted.
4. A reagent clear is run and the volume of EDTA (B) was found.
5. Volume of EDTA required by test, C = (A-B) is ascertained.

Calculation:

Total hardness as $CaCO_3$ mg/L = C x D x 1000 / mL sample.
Where, C = volume of EDTA required by sample
D = mg $CaCO_3$ equivalent to 1mL EDTA titrant

3.4.4.2. Determination of nitrate: Nitrate is the most paramount oxidized kind of nitrogen disturbs that are accessible in ordinary waters. Engineered fertilizers, decayed vegetable and animal matter, private effluents, sewage ooze exchange to arrive, mechanical discharge, leachates from decrease dumps and barometrical washout are the colossal wellsprings of nitrate.

Regardless of the way that it can happen in an extensive variety of water bodies yet it center may go higher in regions close coal mines due to their characteristic source.

Phenol Disulphonic Acid (PDA) method

Principle:

Nitrate responds with Phenol disulphonic corrosive and produces a nitro-subordinate which in soluble arrangement creates yellow shading because of adjustment of its structure. The shading delivered takes after Beer's law and is force corresponding to the centralization of NO_3 present in the example.

Procedure:

1. Adjustment: the colorimeter is aligned utilizing standard nitrate arrangement and alignment bend (absorbance Vs. Fixation) is plotted.

2. Shading advancement:

a. The cleared up test is killed to pH 7.0.

b. Appropriate aliquot of the example is taken in a measuring utencil and vanished to dryness on water shower.

c. The buildup is broken down utilizing glass bar with 2mL phenol disulphonic corrosive reagent. At that point is weakened and exchanged to Nessler's tubes.

d. 8-10mL 12N KOH is included. On the off chance that turbidity builds up the EDTA reagent is included drop-wise till it breaks down.

e. The arrangement is sifted and made up to 100mL. To stay away from turbidity 10mL conc. NH_4OH is included rather than KOH.

f. Clear is set up similarly utilizing refined water as a part of spot of test

g. Then the sample is subjected to colorimetry and the intensity of colour developed at 410nm with a light path of 1cm is read.

Calculation:

The concentration of Nitrate is calculated from the standard calibration curve and the values are reported in mg/L.

3.4.4.3. Determination of phenol: Phenols, chemicals and other normal materials may be unsafe to phyto and zoo-minor fish past certain levels. Regular blends may enter water environment through human waste exchange and present day discharges. Phenols are portrayed as hydroxyl subordinates of benzene, and its united centers happen in family and mechanical wastewaters, trademark misuses and consumable water supplies. Odoriferous and Flawed tasting chlorophenols are molded as a delayed consequence of chlorination of water containing phenol. Phenols may be accessible in unrefined water inferable from the arrival of wastewaters from coke refining plants, the petrochemical business and different distinctive business wanders where phenols serve as intermediates.

Chloroform extraction method:

Principle:

The steam distillable phenols react with 4-aminoantipyrine at a pH of 7.9 in closeness of potassium ferricyanide to outline a tinted antipyrine shading. The shading is isolated from watery course of action with chloroform and the force is measured at 460 nm. This system is material in the center extent of 1 μg/L to 250 μg/L with an affectability of μg/L.

Procedure:

1. Modification: By titration the union of standard phenol is to be measured.
2. Refining: 500 mL test is taken in a recepticle, and 50 mL without phenol refined water is incorporated, in this manner the pH is carried down to 4.0 with $H_3 PO_4$ course of action using methyl orange as a pointer. 5 mL of $CuSO_4$ game plan is incorporated. The course of action is traded to refining cup and 500 mL of distillate is assembled using measuring barrel as authority.
3. Extraction and shading headway:

•500 mL of the distillate is taken containing more than 50 mg phenol and is debilitated to 500 mL in 1 liter measuring glass.

•500 mL of refined water clear and a movement of 500 mL phenol measures containing 5, 10, 20, 30, 40 and 50 μg phenol is taken in independent recepticles.

•12 mL 0.5N NH_4OH course of action is incorporated and the pH of each is adjusted to 7.9 ± 0.1 with phosphate pad. Around 10 mL phosphate support is required. By then it is traded to 1 liter disconnecting funnel, and 3.0 mL 4-aminoantipyrine course of action in each separatory channel is incorporated and mixed well. 3.0 mL of potassium ferricyanide is incorporated and the shading is allowed to make for 15 min

•25 mL chloroform is incorporated each separatory pipe and is shaken for no under 10 times. CHC_{13} concentrate is isolated through channel paper containing 5 g layer of anhydrous $Na_2 SO_4$.

•The dried think clean cells are removed and the absorbance is measured of the example and standard against the unmistakable at 460 nm.

•Absorbance against mg phenol center is plotted and an arrangement curve is drawn. Phenol substance is measured from photometric scrutinizing by using an arrangement twist.

Calculations:

Use of calibration curve,

µg/L, phenol = [(A / B) x 1000]

Where:

A = µg phenol in sample (estimated from calibration curve)

B = mL original sample

3.4.4.4. Determination of sulfate: Sulfate happens in common waters in solvent structure. They begin from oxidation of sulfate mineral, nearness of shale, from natural mixes. Sulfur-bearing mineral are basic in most sedimentary rocks. In damp area, sulfate is promptly filtered from the zone of weathering by penetrating waters and surface keep running off. Sulfate fixation is relied upon to be higher in ranges close coal mines as minerals containing sulfur happen in coal stores.

Ingestion of water containing high centralization of sulfate can have a purgative impact, which is upgraded when sulfate is expended in mix with magnesium. Water containing magnesium sulfate at levels around 1000 mg/L goes about as a laxative in human grown-ups. Taste edge focuses for the most predominant sulfate salts are 200-500mg/L for sodium sulfate, 250-900mg/L for calcium sulfate, and 400-600mg/L for magnesium sulfate.

Gravimetric method with ignition of residue

Principle:

Sulfate is rushed in a hydrochloric destructive (HCl) game plan as barium Sulfate ($BaSO_2$) by the extension of barium chloride ($BaCl_2$). The precipitation is done near the foaming temperature, and after a period of preparing the quicken is isolated, washed with water until free of chloride molecule, touched off or dried, and weighed as ($BaSO_2$).The gravimetric determination of Sulfate is obligated to various bumbles, both positive and negative. Checks provoking high results-suspended matter, silica, nitrite and blocked mother liquor in the quicken are the critical components in positive oversights. Impediments inciting low results-solvent base metal Sulfates regularly yield low results.

Procedure:

1. Ba (+II) is incorporated wealth under acidic conditions, $BaSO_4$ is supported quantitatively. The reaction is allowed to continue for 2 hours or more at 80-90˚C. This is to empower the improvement of BaSO4 jewels (non-filterable) from the initially molded colloidal hurry (for the most part filterable).
2. The rush is washed, and after that dried at 800˚C for a hour. Low pH is relied upon to avoid the precipitation of $BaCO_3$ and $Ba_3 (PO_4)_2$. Positive inclination may happen in light of destructive safe insoluble matter, for instance, silica, Sulphites which may oxidize to Sulfate, and nitrate and chloride which will bring up with barium and co-quicken to a little degree with the barium Sulfate. Negative slant may come to fruition in light of the closeness of certain generous metals (e.g., Cr, Fe) which can shape dissolvable structures with Sulfate.

Calculation:

Mg SO_4^{2-} /L = mg $BaSO_4$ x 411.6/mL sample

3.4.4.5. Determination of phosphate: Diverse sorts of Phosphates get into water source basically through waste water from neighborhood or from compost and cleaning industry. The closeness of phosphate in enormous sums in fresh waters demonstrates pollution through sewage and mechanical wastes. It propels improvement of exacerbation making little scale living creatures. Despite the way that phosphate stances issues in surface waters, its closeness is indispensable for common defilement of wastewaters.

Stannous chloride method:

Principle:

In phosphate investigation the phosphorous in any structure is attempted to change over into orthophosphate frame predominantly by means of corrosive hydrolysis. In acidic condition, orthophosphate responds with ammonium molybdate to shape molybdophosphoric corrosive. It is further diminished to molybdenum blue by including lessening operator, for example, stannous chloride or ascorbic corrosive. The blue shading created after expansion of ammonium molybdate is measured at 690 or 880nm inside 10-12 minutes after advancement of shading by utilizing clear.

The focus is figured from the standard diagram. The power of the blue shaded complex is measured which is specifically corresponding to the grouping of phosphate present in the specimen.

Procedure:

1. Absorbance versus Phosphate center is plotted for the colorimeter using working phosphate course of action and clear plan in this manner the instrument is adjusted.

2. For Total phosphate: Organically combined phosphorus and all phosphate including polyphosphate as at first changed over to orthophosphate by osmosis as given underneath.

3. 100mL of particularly mixed case is taken in a 150mL conelike container and one drop of phenolphthalein pointer is incorporated. If red shading makes, sulphuric destructive course of action is added drop shrewd to just discharge the shading.

4. By then 1mL sulphuric destructive game plan in plenitude is incorporated and foamed gently for no not exactly 90 minutes, adding refined water to keep the volume some place around 25 and 50mL. One drop of phenolphthalein marker is incorporated after it cooled and is murdered to a powerless pink shading with hydroxide plan.

5. 50 ml of the course of action is taken in colorimetry and after that centralization of phosphate is examined from conformity twist.

Calculation:

The concentration is found out from the absorbance vs. Concentration plot.

3.4.4.6. Determination of fluoride: Fluoride has noteworthy part and ideal convergence of it is fancied inside points of confinement as overabundance of it causes fluorosis and when of less fixation it results in dental caries.
SPANDS, a colorimetric strategy, and Ion Selective Electrode technique are by and large used to decide Fluoride content.

Ion selective electrode method:

Principle:

At the point when the fluoride anode is plunged in test whose fixation is to be measured, a potential is built up by the nearness of fluoride particles by any cutting edge pH meter having an extended millivolt scale. Measuring the created potential aides in finding the fixation.

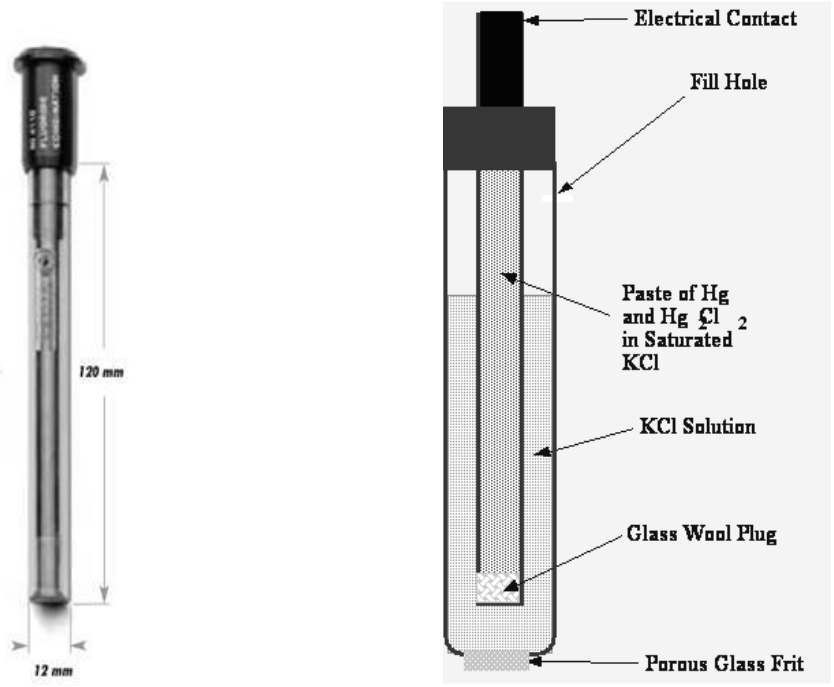

Figure 3.6. Fluoride electrode and calomel electrode

Procedure:

1. Adjustment: the anode is aligned utilizing the standard fluoride arrangement.

2. Association of the cathodes to meter and for further operations of the instrument is done according to the direction manual supplied by the producer.

3. The cathode incline is checked with the particle meter (59.16mV for monovalent particles and 29.58mV for divalent particles at 25°C).

4. 50 to 100mL of test is taken in a 150mL plastic measuring glass. TISAB is included.

5. Terminal is flushed, smudged dry and set in the example. Blending is done completely and the consistent perusing on the meter is noted.

6. Recalibration is done in at regular intervals.

7. Direct estimation results can be confirmed by a known expansion system. The known option technique includes including a standard of known fixation to an example arrangement. From the adjustment in anode potential prior and then afterward expansion, the first example fixation is resolved.

Calculation:

The concentration in mg/L is obtained directly from the specific ion meter.

3.4.5. DETERMINATION OF ORGANIC PARAMETERS

The most imperative parameters that bear significance to the natural action and the life in the amphibian media are Dissolved Oxygen, Bio-chemical Oxygen Demand, Chemical Oxygen Demand and the Total Organic Carbon. Consequently these parameters are given equivalent significance with that of the inorganic non-metallic substance and are resolved in this work.

3.4.5.1. Determination of dissolved Oxygen: Broken down Oxygen is the oxygen substance of any water body. Every sea-going creature rely on upon this to support. So DO level evaluates nature of crude water to keep beware of contamination.

Winkler method with azide modification:

Principle:

Oxygen present in test quickly oxidizes the scattered divalent manganous hydroxide to its higher valency, which is accelerated as a cocoa hydrated oxide after the expansion of NaOH/KOH and Kl. Upon fermentation, manganese returns to divalent state and frees iodine from Kl identical to the first DO content. The freed iodine is titrated against $Na_2S_2O_3$ (N/40) utilizing starch as a pointer. The synthetic responses required in the strategy are given beneath:

1. $MnSO_4 + 2KOH \Rightarrow Mn(OH)_2 + K_2SO_4$ (white ppt)
2. $2Mn(OH)_2 + O_2 \Rightarrow 2\ MnO(OH)_2$ (Brown ppt)
3. $MnO(OH)_2 + 2H_2SO_4 \Rightarrow Mn(SO_4)_2 + 3H_2O$

4. $Mn(SO_4)_2 + 2\ Kl \Rightarrow MnSO_4 + K_2SO_4 + l2$

5. $2Na_2S_2O_3.5H_2O + l2 \Rightarrow Na_2S_4O_6 + 2NaCl + 10H_2O$

6. $2NaN_3 + H_2SO_4 \Rightarrow 2HN_3 + Na_2SO_4$

7. $HNO_2 + HN_3 \Rightarrow N_2 + N_2O + H_2O$

Procedure:

1. Sample is collected in a BOD bottle.

2. 1mL $MnSO_4$ is added followed by 1mL of alkali-iodide-azide reagent to a sample collected in 250 to 300mL bottle up to the brim and then is repeatedly inverted to mix well.

3. The precipitate is allowed to settle. (It is white if the sample is devoid of oxygen, and becomes increasingly brown with rising oxygen content.)

4. 1mL conc. H_2SO_4 is added and the stopper is replaced and mixed well till precipitate goes into solution.

5. 201mL of this solution is taken in a conical flask and is titrated against standard $Na_2S_2O_3$ solution using starch (2mL) as an indicator. When 1mL MnSO4 followed by 1mL alkali-iodide-azide reagent is added to the samples as in (2) above, 2mL of original sample is lost. Therefore 201mL is taken for titration which will correspond to 200mL of original sample. 200 x 300/ (300-1) = 201mL

Calculation:

1mL of 0.025N $Na_2S_2O_3$ = 0.2mg of O_2
DO in mg/L = (0.2 x 100) x (0.025N) ml of thiosulphate / 200

3.4.5.2. Determination of biochemical oxygen demand: The Biochemical Oxygen Demand (BOD) is the oxygen requirement for aerobic oxidation of decomposable organic matter and certain inorganic materials in water, polluted waters and wastewater under controlled conditions of temperature and incubation period.

Principle:

This test measures the oxygen used for the biochemical corruption of natural material (carbonaceous interest) and oxidation of inorganic material, for example, sulfides and ferrous particles amid a predetermined brooding period. It additionally measures the oxygen used to oxidize lessened types of nitrogen (nitrogenous interest) unless their oxidation is avoided by an inhibitor. Temperature impacts are held steady by playing out a test at altered temperature. The approach of BOD test is to figure a distinction amongst introductory and last Do of the specimens hatching. Least 1.5 L of test is required for the test. DO is evaluation by iodometric titration.

Figure 3.7. BOD incubator

Procedure:

Preparation of dilution water:

1. Distilled water, tap or receiving-stream water free of biodegradable organics and bio-inhibitory substances such as chlorine or heavy metals are used.

2. The required volume of dilution water is aerated in a suitable bottle by bubbling clean-filtered compressed air for sufficient time to attain DO saturation at room temperature or at 20ºC/27ºC.

3. 1mL each of phosphate buffer, magnesium sulphate, calcium chloride and ferric chloride are added to solutions in that order for each Litre of dilution water.

4. For wastes which are not expected to have sufficient microbial population, seed is essential. BOD of the seeding material is determined.

Sample preparation:

1. The sample is neutralised to pH 7, if it is highly acidic or alkaline.

2. The sample is freed from residual chlorine using $Na_2S_2O_3$ solution.

3. Samples are brought down to 20 ± 1ºC before making dilutions.

4. If nitrification inhibition is desired, 3mg 2-chloro-6-(trichloromethyl) pyridine (TCMP) is added to each 300mL bottle before capping or sufficient amount to the dilution water is added to make a final concentration of 30mg/L.

5. Samples having high DO contents, DO ≥ 9mg/L are treated to reduce the DO content to saturation at 20ºC. The sample is agitated or aerated with clean, filtered compressed air.

6. Dilutions that result in a residual DO of at least 1mg/L and DO uptake of at least 2mg/L produces reliable results. So several dilutions are made to pre-treated sample so as to obtain about 50% depletion of DO or DO uptake of 2mg/L.

Sample processing:

1. The weakened or undiluted example is guided in three named containers and plug quickly.
2. DO of 1 jug is resolved at first and the other 2 jugs are kept at 20ºC for 3days.
3. The O2 utilization is measured in weakening water.
4. Body of seed clear is resolved for revision of genuine BOD.
5. DO in a BOD test can is resolved in the clear on introductory day and end of brooding period by Winkler strategy as depicted for DO estimation.

Calculations:

BOD of the sample is calculated as follows:

a. When dilution water is not seeded

BOD as O_2 mg/L = {(D1 –D2) x 100}/ % dilution

b. When dilution is seeded

BOD as O_2 mg/L = {(D1 – D2) – (B1 –B2) x 100}/ % dilution

Where,

D1 = DO of sample immediately after preparation, mg/L

D2 = DO of sample after incubation period, mg/L

B1 = DO of blank (seeded dilution water) before incubation, mg/L

B2 = DO of blank (seeded dilution water) after incubation, mg/L

3.4.5.3. Determination of chemical oxygen demand: Substance Oxygen Demand (COD) test decides the oxygen prerequisite likeness natural matter that is defenseless to oxidation with the assistance of a solid concoction oxidant. It is a vital, quickly measured parameter which gives the method for measuring natural quality for streams and dirtied water bodies. The test can be connected experimentally to BOD, natural carbon or natural matter in tests from a particular source considering its impediments. This test is moderately simple, exact, and quick.

Open reflux method:

This method uses potassium dichromate for oxidation. The organic matter gets oxidised completely by potassium dichromate ($K_2Cr_2O_7$) with silver sulphate as catalyst in the presence of concentrated H_2SO_4 to produce CO_2 and H_2O. The excess $K_2Cr_2O_2$ remaining after the reaction is titrated with ferrous ammonium sulphate [Fe $(NH_4)2(SO_4)_2$]. The dichromate consumed gives the oxygen (O_2) required for oxidation of the organic matter. The chemical reactions involved in the method are as under:

1. 2K2Cr2O2 + 8 H2SO4 □ 2 K2 SO4 + 2 Cr2 (SO4)3 + 8 H2O + 3O2
2. C6H12O6 + 6O2 □ 6CO2+ 6H2O
3. Cr2O7-- + 6Fe++ + 14H+ □ 6Fe3+ + 2Cr3+ + 7H2O

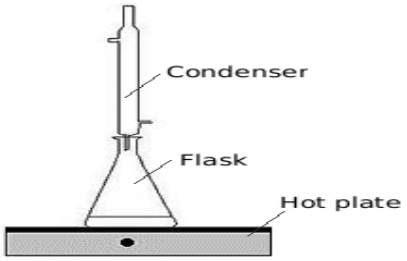

Figure 3.8.Reflux apparatus

Procedure:

Sample preparation:

1. All samples high in solids are blended for 2 minutes at high speed and stirred when an aliquot is taken for analysis.

2. Proper volume of sample is selected based on expected COD range. (E.g. for COD range of 50-500 mg/L take 25-50mL of sample)

Reflux of samples:

1. 0.4g $HgSO_4$ is added to a 250mL reflux sample.
2. 20mL sample or an aliquot of sample diluted to 20mL with distilled water is added to it and is mixed well.

3. Clean pumice stones or glass beads are added.

4. 10mL 0.25N (0.04167M) $K_2Cr_2O_7$ solution is added and mixed.

5. 30mL concentrated H_2SO_4 containing Ag_2SO_4 is added slowly and thoroughly. This slow addition along with swirling prevents fatty acids to escape due to generation of high temperature. Alternatively a flask is attached to condenser with water flowing and then H_2SO_4 is added slowly through condenser to avoid escape of volatile organic substance due to generation of heat.

6. Mixing is performed and if the colour turned green, both fresh sample is taken with lesser aliquot or more potassium dichromate and acid is added.

7. The flask is attached condenser. The contents are mixed before heating.

8. The sample is left to be refluxed for a minimum of 2 hours. And then is cooled.

9. The reflux condenser is disconnected and the mixture is diluted to about twice its volume with distilled water. After cooling down to room temperature the excess $K_2 Cr_2 O_7$ is titrated with 0.1M FAS using 2-3 drops of ferroin indicator. The sharp colour change from blue green to reddish brown indicated the endpoint.

10. The same quantity of ferroin indicator is used for all titrations.

11. Blank is also refluxed in the same manner using distilled water instead of sample.

Calculations:

COD, mg/L = (A-B) x M x 8000 / Volume of Sample in ml

Where:

A: mL of titrant used for sample

B: mL of titrant used for blank

M: normality of ferrous ammonium sul

CHAPTER-4

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

4.1. Balanda coal washery, Talcher

Sample points: 1. Raw water
2. Fine coal jig water
3. Coarse coal jig water
4. Outlet stream

Table: 4.1 Results of water samples from Balanda coal washery

Sl. No.	Parameter	Sample 1	Sample 2	Sample 3	Sample 4	Below detection limit	MoEF-Schedule VI Indian standards (2006)
1	Color	Acceptable	Acceptable	Acceptable	Acceptable		Acceptable
2	Odor	Acceptable	Acceptable	Acceptable	Acceptable		Acceptable
3	pH	6.7	4.44	4.4	4.3		5.5-9.0
4	Temperature	30.4	31.7	31.8	31.9		---
5	Turbidity(NTU)	124	184	184	163		10
6	Conductivity(mS/cm)	0.251	0.269	0.261	0.267		300
7	Salinity(PSU)	0.2	0.2	0.2	0.2		---
8	TDS (mg/l)	0.133	0.94	0.889	0.807		500
9	Hardness	152	124	142	130		600
10	Nitrate	1.9	0.9	0.7	0.6		100
11	Phenol	0.08	-	-	-		1.002
12	Sulfate	32	36	38	34		200
13	Phosphate	0.39	0.012	0.011	0.002		1
14	Fluoride	0.34	0.35	0.05	0.08		1.5
15	DO	6.8	7.4	7.7	7.7		18
16	BOD	536	508	448	412		30
17	COD	1936	1819	1672	-		250

NB: mg/l is taken as the unit for all the parameters until specified and BDL is below detectable limit

4.2. Ib Valley coal washery,Jharsuguda

Sample points: 1. Raw water
2. Fine coal jig water
3. Coarse coal jig water
4. Outlet stream

Table: 4.2 Results of water samples from Ib valley coal washery

Sl/No	Parameter	Sample 1	Sample 2	Sample 3	Sample 4	Below detection limit	MoEF-Schedule VI Indian standards (2006)
1	Color	Acceptable	Acceptable	Acceptable	Acceptable		Acceptable
2	Odor	Acceptable	Acceptable	Acceptable	Acceptable		Acceptable
3	pH	6.7	6.28	6.32	6.24	<0.01	5.5-9.0
4	Temperature	29.7	31	32.1	31.4		---
5	Turbidity(NTU)	115	128	139	108		10
6	Conductivity(mS/cm)	0.24	0.258	0.263	0.260		300
7	Salinity(PSU)	0.7	0.7	0.7	0.7		---
8	TDS (mg/l)	0.136	0.95	0.890	0.810		500
9	Hardness	130	144	132	164		600
10	Nitrate	1.9	0.9	0.7	0.6		100
11	Phenol	-	-	-	-		1.002
12	Sulfate	35	36	50	40		200
13	Phosphate	0.002	0.034	-	0.046		1
14	Fluoride	0.04	0.05	0.06	0.03		1.5
15	DO	6.4	7.11	7.14	7.17		18
16	BOD	456	592	400	744		30
17	COD	1312	1216	1088	928		250

NB: mg/l is taken as the unit for all the parameters until specified and BDL is below detectable limit

4.3. Himgir coal washery, Sundergarh

Sample points: 1. Raw water
2. Fine coal jig water
3. Coarse coal jig water
4. Outlet stream

Table: 4.3 Results of water samples from Himgir coal washery

Sl/No	Parameter	Sample 1	Sample 2	Sample 3	Sample 4	Below detection limit	MoEF-Schedule VI Indian standards (2006)
1	Color	Acceptable	Acceptable	Acceptable	Acceptable		Acceptable
2	Odor	Acceptable	Acceptable	Acceptable	Acceptable		Acceptable
3	pH	7.6	6.31	6.4	6.4	<0.01	5.5-9.0
4	Temperature	31.2	31.6	31.8	31.1		
5	Turbidity(NTU)	131	143	146	140		10
6	Conductivity(mS/cm)	0.260	0.251	0.258	0.269		300
7	Salinity(PSU)	0.5	0.5	0.5	0.5		---
8	TDS (mg/l)	0.13	0.29	0.24	0.21		500
9	Hardness	162	154	130	142		600
10	Nitrate	1.9	0.9	0.7	0.6		100
11	Phenol	-	-	-	-		1.002
12	Sulfate	110	55	40	34		200
13	Phosphate	0.04	1.5	1.2	0.7		1
14	Fluoride	0.5	1.3	1.2	1.1		1.5
15	DO	6.5	8.42	8.47	8.47		18
16	BOD	704	332	784	404		30
17	COD	1248	1376	1600	-		250

NB: mg/l is taken as the unit for all the parameters until specified and BDL is below detectable limit

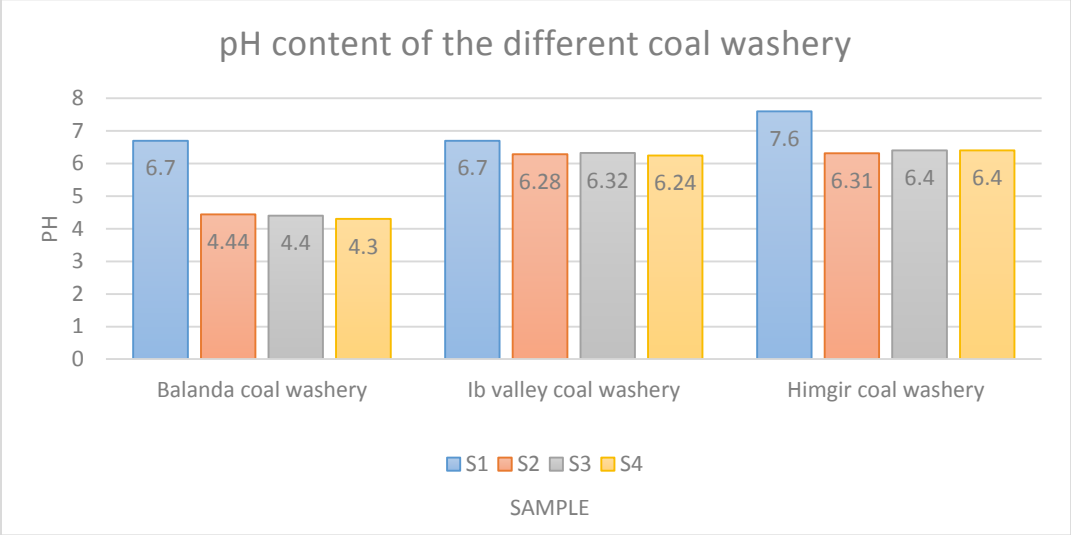

Fig 4.1. pH content of the different water samples

It may be observed from Figure 4.1 that the pH in the water samples ranged from 4.3 to 7.6 in the study area. The water sample S4 of Balanda coal washery had a quite low pH in comparison with other samples. The pH of all samples except S2-S4 of Balanda coal washery were within the permissible limit. The prescribed limit of pH is 5.5-9.0 (as per MOEF Schedule VI Indian Standard, 2006).

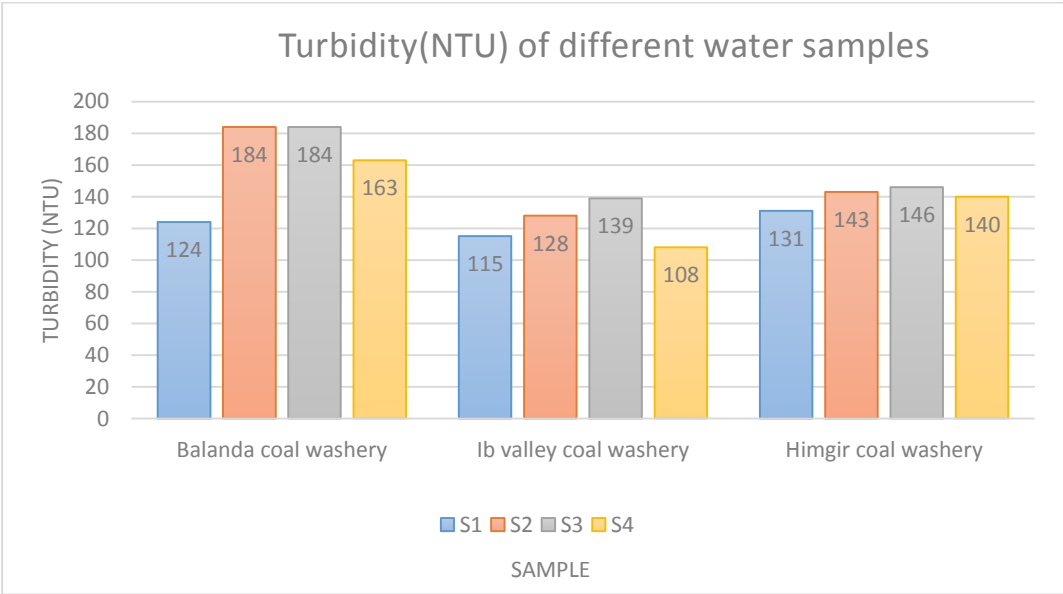

Fig 4.2. Turbidity of different water samples

It may be observed from Figure 4.2 that the turbidity ranged from 108 to 184 NTU in the study area. The water samples S1, S2, S3 and S4 from three coal washeries had turbidity beyond the permissible limit. The prescribed limit of turbidity is 10 NTU (as per MOEF Schedule VI Indian Standard, 2006).

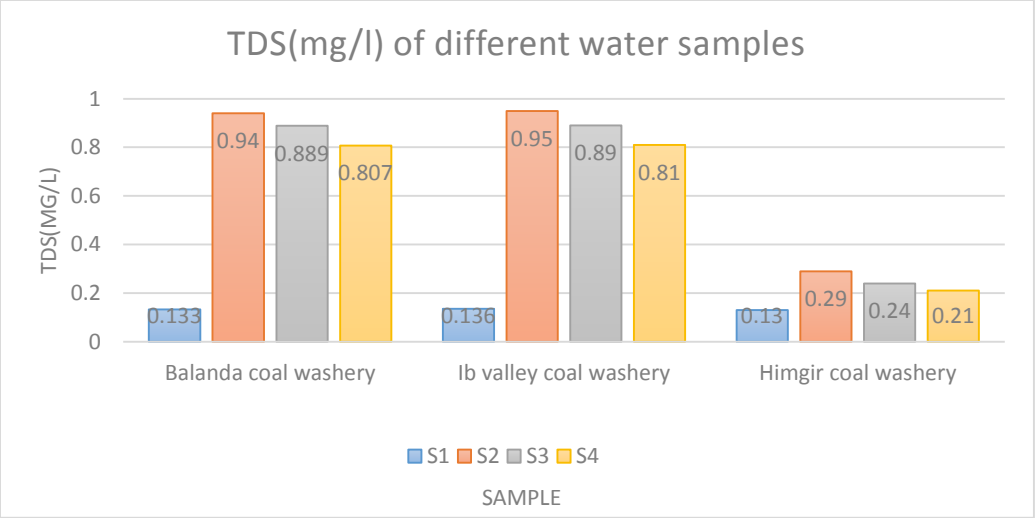

Fig 4.3. TDS of different water samples

It may be observed from Figure 4.3 that the Total Dissolved Solids ranged from 0.13 to 0.95 mg/l in the study area. The water sample S2 of Ib valley coal washery had a high TDS in comparison to other samples. However the value was within the permissible limit. The TDS of all samples water samples was within the limits. The prescribed limit of TDS is 500 mg/l.

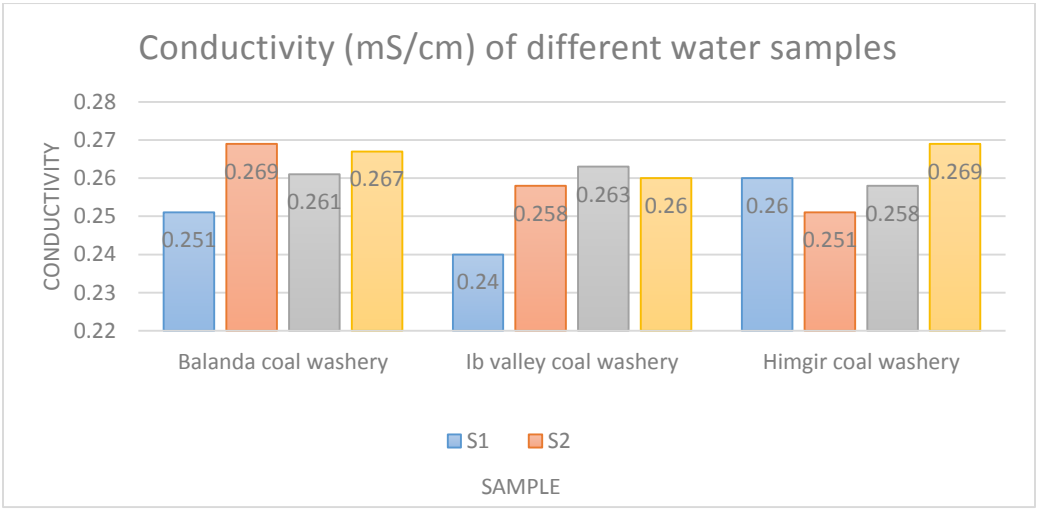

Fig 4.4. Conductivity of different water samples

It may be observed from Figure 4.4 that the Electrical Conductivity ranged from 0.24 to 0.269 mS/cm in the study area. The water sample S2 of Balanda coal washery and S4 of Himgir coal washery had a high conductivity in comparison to other samples. The conductivity of all other water samples was within the limits. The prescribed limit of conductivity is 300 mS/cm.

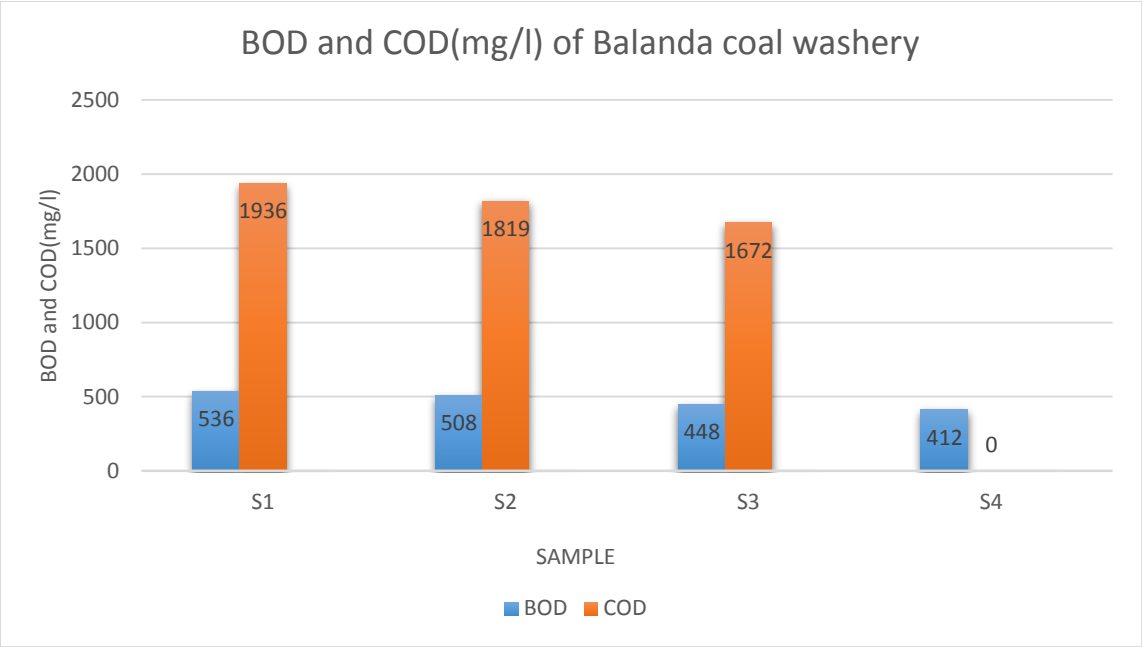

Fig 4.5.BOD and COD of Balanda coal washery, Talcher

It may be observed from Figure 4.5 that the Biological oxygen demand (BOD) of the water samples ranged from 412 to 536 mg/l in the study area. The BOD of S1 from Balanda coal washery was comparatively higher than the other water samples. However, the values were all beyond the permissible limit. The BOD of S-4 was lowest among all the water samples. The prescribed limit of BOD is 30 mg/l.

The COD of the water samples ranged from 0 to 1936 mg/l in the study area. The COD of all water samples were beyond the permissible limit except S4. The prescribed limit of COD is 250 mg/l.

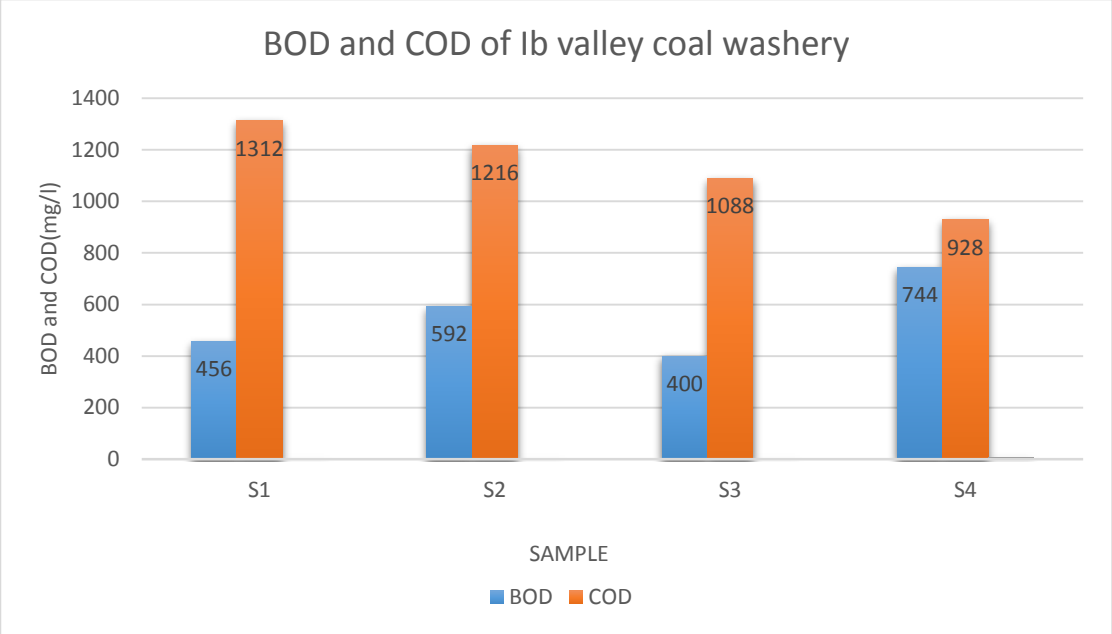

Fig 4.6. BOD and COD of Ib valley coal washery (Samleshwari), Jharsuguda

It may be observed from Figure 4.6 that the Biological oxygen demand (BOD) of the water samples ranged from 400 to 744 mg/l in the study area. The BOD of S4 from Ib valley coal washery was comparatively higher than the other water samples. However, the values were all beyond the permissible limit. The BOD of S-3 was lowest among all the water samples. The prescribed limit of BOD is 30 mg/l.

The COD of the water samples ranged from 928 to 1312 mg/l in the study area. The COD of all water samples were beyond the permissible limit. The prescribed limit of COD is 250 mg/l.

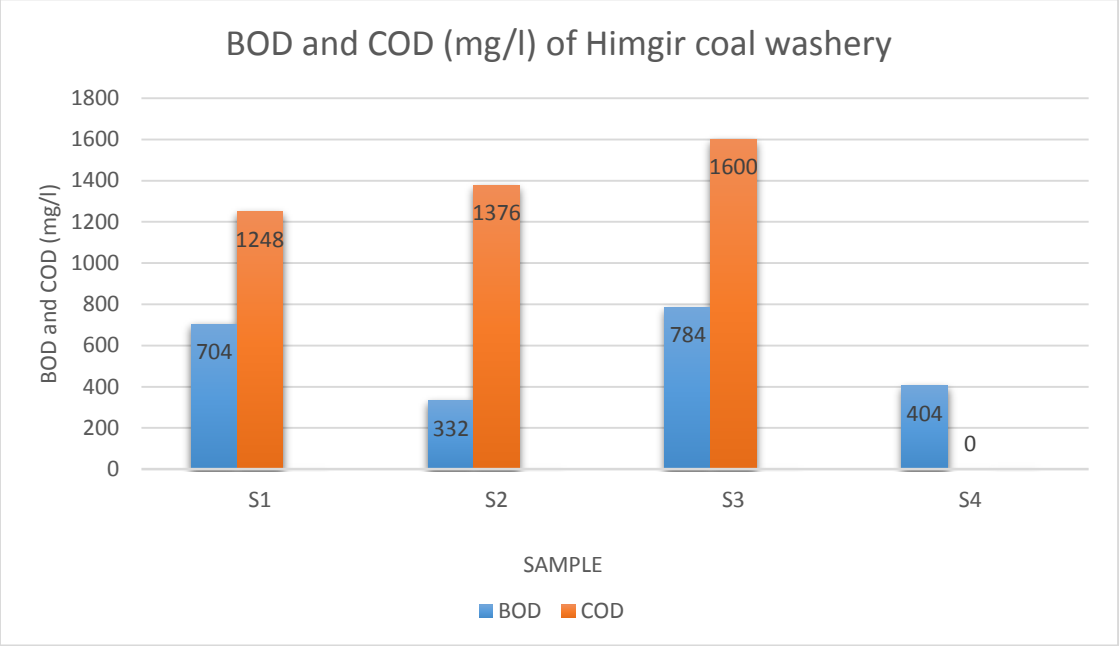

Fig.4.7. BOD and COD of Himgir coal washery, Sundergarh

It may be observed from Figure 4.6 that the Biological oxygen demand (BOD) of the water samples ranged from 332 to 784 mg/l in the study area. The BOD of S3 from Himgir coal washery was comparatively higher than the other water samples. However, the values were all beyond the permissible limit. The BOD of S-2 was lowest among all the water samples. The prescribed limit of BOD is 30 mg/l.

The COD of the water samples ranged from 0 to 1600 mg/l in the study area. The COD of all water samples were beyond the permissible limit except S4. The prescribed limit of COD is 250 mg/l.

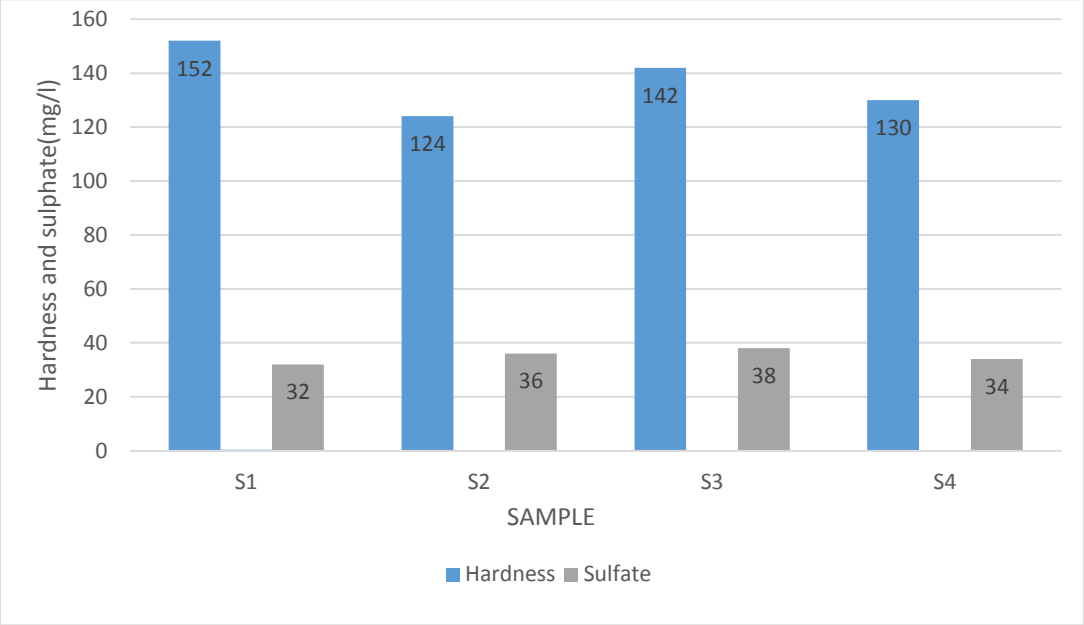

Fig 4.8. Hardness and sulfate of Balanda coal washery, Talcher

It may be observed from Figure 4.8 that the Total Hardness ranged from 124 to 152 mg/l in the study area. The total hardness of S1 from Balanda coal washery was comparatively higher than the other water samples. The total hardness of all water samples was within the limit. The prescribed limit of total hardness is 600 mg/l.

The sulfate content of the water samples ranged from 32 to 38 mg/l in the study area. The sulfate content of S2 from Balanda coal washery was comparatively higher than the other water samples. However, the value was within the permissible limit. The sulfate content of all water samples was within the limit. The prescribed limit of sulfate is 200 mg/l.

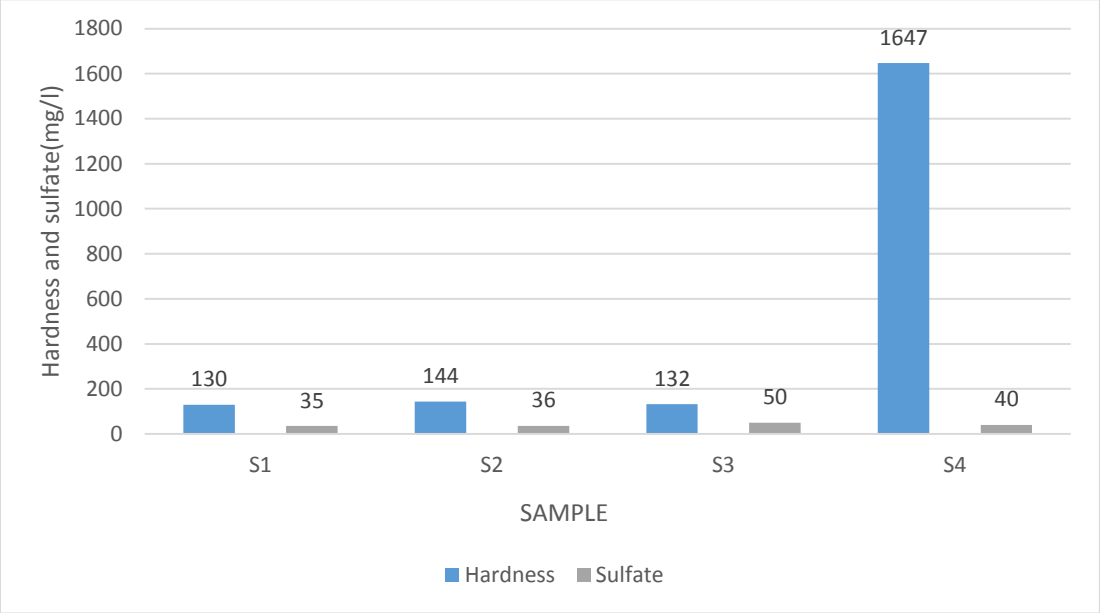

Fig 4.9. Hardness and sulfate of Ib valley coal washery (Samleshwari), Jharsuguda

It may be observed from Figure 4.9 that the Total Hardness ranged from 130 to 1674 mg/l in the study area. The total hardness of S4 from Ib valley coal washery was comparatively very high than the other water samples. The total hardness of water samples S1, S2 and S3 was within the limit. The prescribed limit of total hardness is 600 mg/l.

The sulfate content of the water samples ranged from 35 to 50 mg/l in the study area. The sulfate content of S3 from Ib valley coal washery was comparatively higher than the other water samples. However, the value was within the permissible limit. The sulfate content of all water samples was within the limit. The prescribed limit of sulfate is 200 mg/l.

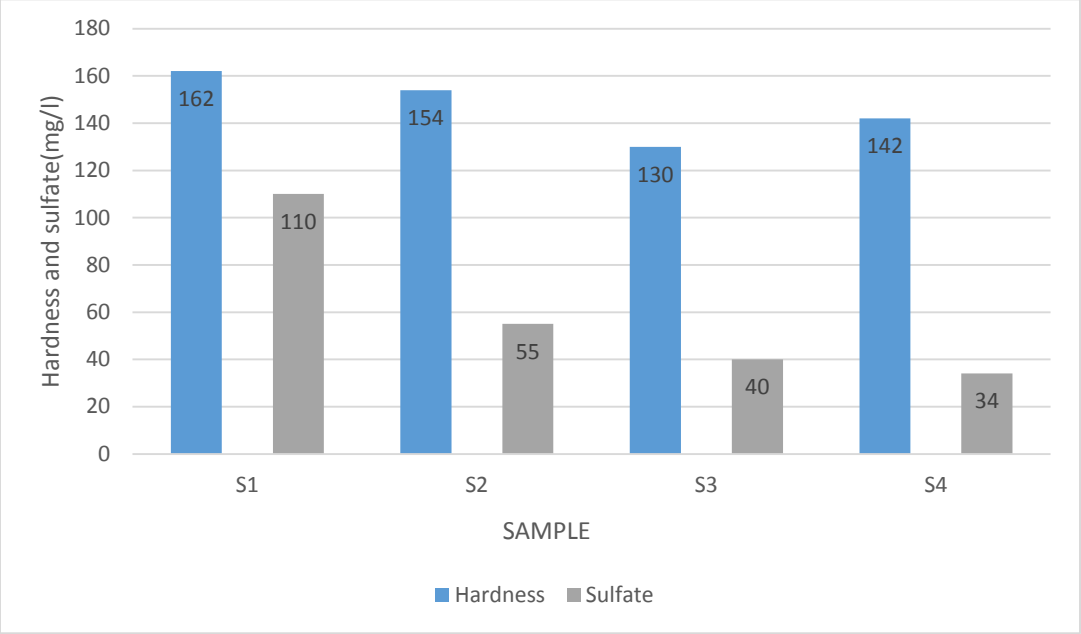

Fig.4.10. Hardness and sulfate of Himgir coal washery, Sundergarh

It may be observed from Figure 4.10 that the Total Hardness ranged from 130 to 162 mg/l in the study area. The total hardness of S1 from Himgir coal washery was comparatively higher than the other water samples. The total hardness of all water samples was within the limit. The prescribed limit of total hardness is 600 mg/l.

The sulfate content of the water samples ranged from 34 to 110 mg/l in the study area. The sulfate content of S1 from Himgir coal washery was comparatively higher than the other water samples. However, the value was within the permissible limit. The sulfate content of all water samples was within the limit. The prescribed limit of sulfate is 200 mg/l.

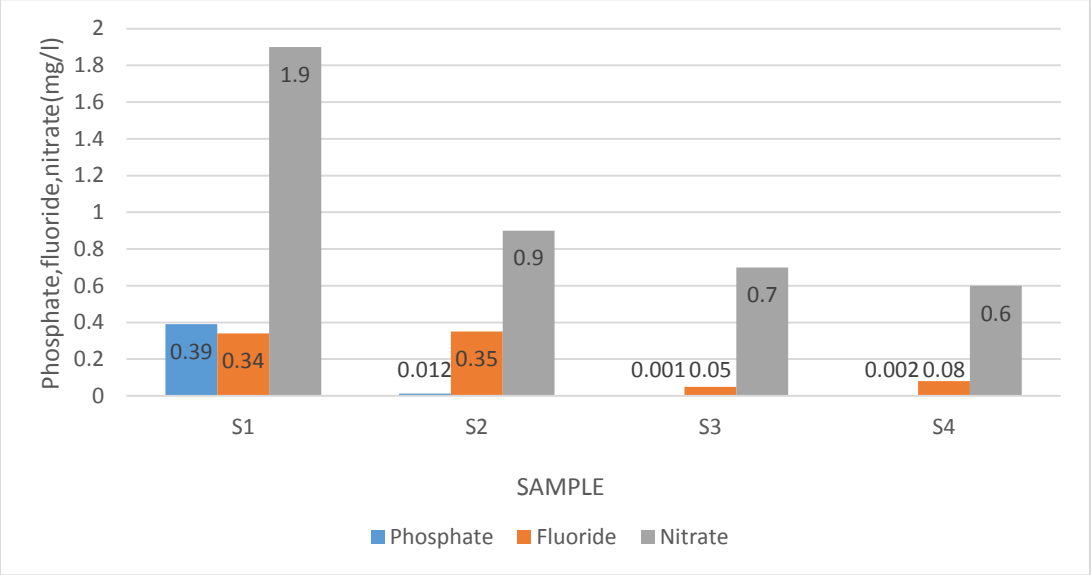

Fig 4.11.Phospahte, fluoride and nitrate of Balanda coal washery, Talcher

It may be observed from Figure 4.11 that the phosphate varied from 0.001 to 0.39 mg/l in the study area. The phosphate content of all water samples was within the permissible limit. The phosphate content of S3 was lowest among all the water samples. The prescribed limit of phosphate is 1 mg/l.

The fluoride content in the water samples ranged from 0.05 to 0.35 mg/l in the study area. The water sample S2 had a high fluoride content which was comparatively higher than the other water samples. The fluoride content of all samples was within the limit. The prescribed limit of fluoride is 2 mg/l.

The nitrate content ranged from 0.6 to 1.9 mg/l in the study area. The nitrate of S1 was comparatively higher than the other water samples. However, the value was within the permissible limit. The nitrate content of all water samples was within the limit. The prescribed limit of nitrate is 100 mg/l.

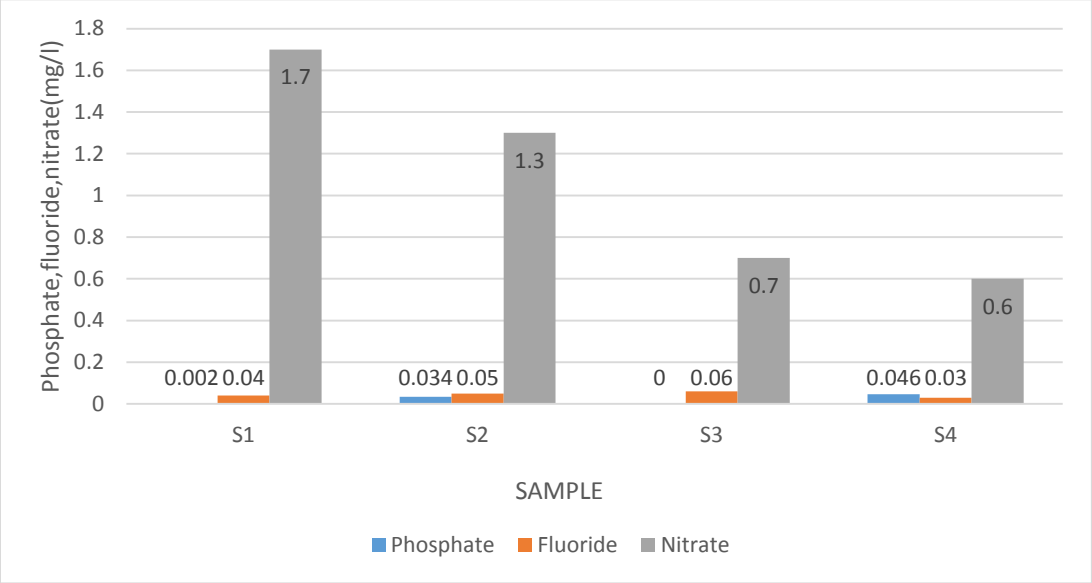

Fig 4.12. Phosphate, fluoride and nitrate of Ib valley coal washery, Jharsuguda

It may be observed from Figure 4.12 that the phosphate varied from 0 to 0.046 mg/l in the study area. The phosphate content of all water samples was within the permissible limit. The phosphate content of S3 was lowest among all the water samples. The prescribed limit of phosphate is 1 mg/l.

The fluoride content in the water samples ranged from 0.06 to 0.03 mg/l in the study area. The water sample S3 had a high fluoride content which was comparatively higher than the other water samples. The fluoride content of all samples was within the limit. The prescribed limit of fluoride is 2 mg/l.

The nitrate content ranged from 0.6 to 1.7 mg/l in the study area. The nitrate of S1 was comparatively higher than the other water samples. However, the value was within the permissible limit. The nitrate content of all water samples was within the limit. The prescribed limit of nitrate is 100 mg/l.

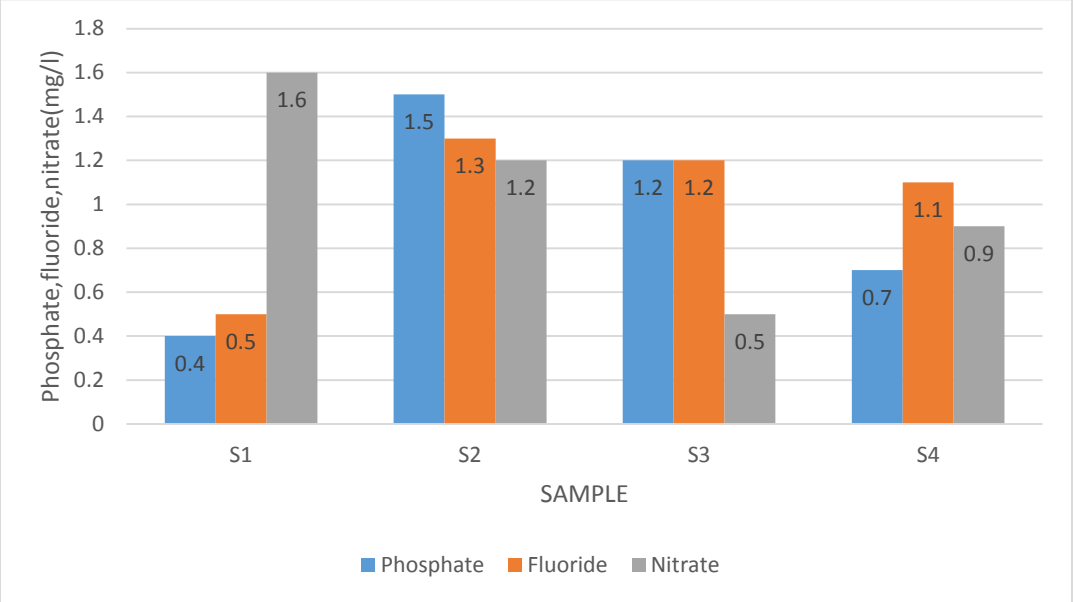

Fig.4.13. Phosphate, fluoride and nitrate of Himgir coal washery, Sundergarh

It may be observed from Figure 4.13 that the phosphate varied from 0.4 to 1.5 mg/l in the study area. The phosphate content of S1 and S4 was within the permissible limit. The phosphate content of S2 and S3 was highest among the water samples. The prescribed limit of phosphate is 1 mg/l.

The fluoride content in the water samples ranged from 0.5 to 1.3 mg/l in the study area. The water sample S2 had a high fluoride content which was comparatively higher than the other water samples. The fluoride content of all samples was within the limit. The prescribed limit of fluoride is 2 mg/l.

The nitrate content ranged from 0.9 to 1.6 mg/l in the study area. The nitrate of S1 was comparatively higher than the other water samples. However, the value was within the permissible limit. The nitrate content of all water samples was within the limit. The prescribed limit of nitrate is 100 mg/l.

CHAPTER-5
CONCLUSIONS

CONCLUSIONS

In this present work, water samples were collected from three coal washeries namely Balanda coal washery, Talcher, Ib Valley Coal Washery (Samleshwari), Jharsuguda, Himgir coal washery, Sundergarh of Mahanadi Coalfields Ltd (MCL). A careful study into table and figure reveals the water quality of water samples S-1, S-2, S-3 and S-4 with respect to various water quality parameters. Based on the Water quality analysis the following conclusions were made:

Water samples were gathered from three coal washeries which are Balanda coal washery, Talcher, Ib Valley Coal Washery (Samleshwari), Jharsuguda, Himgir coal washery, Sundergarh of Mahanadi Coalfields Ltd (MCL). Based on the Water quality analysis the following conclusions were made:
In this present work, water samples were gathered from three coal washeries namely Balanda coal washery, Talcher, Ib Valley Coal Washery (Samleshwari), Jharsuguda, Himgir coal washery, Sundergarh of *Mahanadi Coalfields Ltd (MCL)* analysed for 17 water quality parameters using procedure of APHA,1998. Based on the water quality analysis the following conclusions were made:

In Balanda coal washery, Talcher all the water samples were examined and found that the pH of S2, S3 and S4 had a quite low pH which is acidic and tends to be corrosive but the pH of S4 was within the permissible limit. MOEF Schedule VI Indian Standard (2006) indicates that it ought to be inside 5.5-9.0..Also the water samples S1, S2, S3 and S4 (108 to 184 NTU) had turbidity beyond the permissible limit. MOEF Schedule VI Indian Standard (2006) indicates that it ought to be inside 10 NTU. The parameters like TDS and conductivity were also within the permissible limit. The BOD of S1 was comparatively higher but all water samples were beyond the permissible limit and COD of all water samples were beyond the permissible limit except S4. The water sample S1 had a very high content of hardness in comparison to other samples but parameters of all samples like sulfate, phospahte, fluoride and nitrate were within the standard limits.
In Ib valley coal washery (Samleshwari), Jharsuguda all the water tests were investigated and found that the pH all samples were within the permissible limit. Also the water samples S1, S2, S3 and S4 (130 to 1674 NTU) had turbidity beyond the permissible limit but some of the parameters like TDS and conductivity was also within the permissible limit. The BOD of S4 was comparatively higher but all water samples was beyond the permissible limit and COD of all water samples was beyond

the permissible limit. The water sample S4 had a very high content of hardness in comparison to other samples but parameters of all samples like sulfate, phosphate, fluoride and nitrate were within the standard limits.

In Himgir coal washery, Sundergarh all the water samples were analyzed and found that the pH of all samples were within the permissible limit. . Also the water samples S1, S2, S3 and S4 (130 to 162 NTU) had turbidity beyond the permissible limit but some of the parameters like TDS and conductivity was also within the permissible limit. The BOD of S3 was comparatively higher but for all other water samples were beyond the permissible limit and COD of all water samples was beyond the permissible limit but parameters like sulfate, phosphate, fluoride and nitrate were within the standard limits.

Based on the above observations and conclusions, it can be inferred that treatment for some of the water quality parameters is highly required. So pH can be treated by soda ash (sodium carbonate) and sodium hydroxide which raise the pH of water to near neutral when injected into a water system and also neutralizing filter is used if drinking water is acidic (low pH).Using suitable cost effectives primary and secondary treatment, sedimentation and coagulation treatment as well as chemical treatment the TDS and turbidity, and pH control BOD and COD can be removed substantially /reduced below permissible limits. Hardness can be treated by using chemical water softeners and mechanical water softeners which alter calcium ions so they cannot cause lime-scaling. It is also recommended to use appropriate low cost water treatment options for treating objectionable parameters before water use/discharge receiving water bodies.

CHAPTER-6
REFERENCES

REFERENCES

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